Red Pine Provenance Study in Eastern Nebraska

John A. Sprackling and Ralph A. Read

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Abstract

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An 11-year provenance test of red pine in eastern Nebraska, with 54 rangewide origins, revealed that heights and growth rates differed significantly among origins, but tree form, needle length, and foliage color were uniform. No geographic patterns of variation were identifiable. A fast-growing St. Philomene, Quebec origin is recommended for windbreak and landscape plantings in eastern Nebraska.

Keywords: *Pinus resinosa*, provenances, windbreaks, ornamentals, growth, tree form.

Preface

This provenance study is one of a dozen experimental plantations of various tree species established on the Horning State Farm near Plattsmouth, Nebraska, which is administered by the Department of Forestry of the University of Nebraska. The USDA Forest Service, through its Rocky Mountain Forest and Range Experiment Station Research Work Unit at Lincoln, cooperates with the Nebraska Agricultural Experiment Station in research conducted on this experimental area.

The specific purpose of this work was to find and develop better adapted trees for use in all kinds of plantings, environmental and commercial, throughout Nebraska and the Central Plains. Such provenance studies of different species provide plants of known origin for evaluation of adaptability and genetic variation, and for selection, propagation, and breeding for resistance to disease and insect pests.

The diversity of tree planting materials under study at this and many other locations in the Plains was made possible through cooperation in a Regional Tree Improvement Project (NC-99, formerly NC-51) of the North Central States Agricultural Experiment Stations.

Credits are due Jonathan W. Wright, Professor of Forestry, Michigan State University, for initiating the Regional study and providing the planting stock, and to Walter T. Bagley, Associate Professor of Forestry, University of Nebraska, for cooperation in planting and maintenance of the plantation.

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Rocky Mountain Forest and Range Experiment Station[1]

[1]*Central headquarters is maintained at Fort Collins, in cooperation with Colorado State University. Research reported here was conducted at the Station's Research Work Unit at Lincoln, in cooperation with the University of Nebraska.*

Contents

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Red pine (*Pinus resinosa* Ait.) grows in the northern forest region of North America in an east-west belt approximately 1,500 miles long and 500 miles wide from Newfoundland and Pennsylvania to northwestern Minnesota and southeastern Manitoba (fig. 1). The species is considered to be relatively old, with little variation in morphology throughout its range (Fowler and Lester 1970).

Red pine progeny for this provenance test in eastern Nebraska encompassed a wide range of seed sources. Objectives of the study were to determine the variation, adaptability, and growth of red pine when introduced to the Central Plains. Information thus gained can be used to recommend better-adapted red pine origins for windbreaks, Christmas tree plantations, and landscaping projects in this area. This study also provides information and materials necessary for future tree breeding programs with red pine.

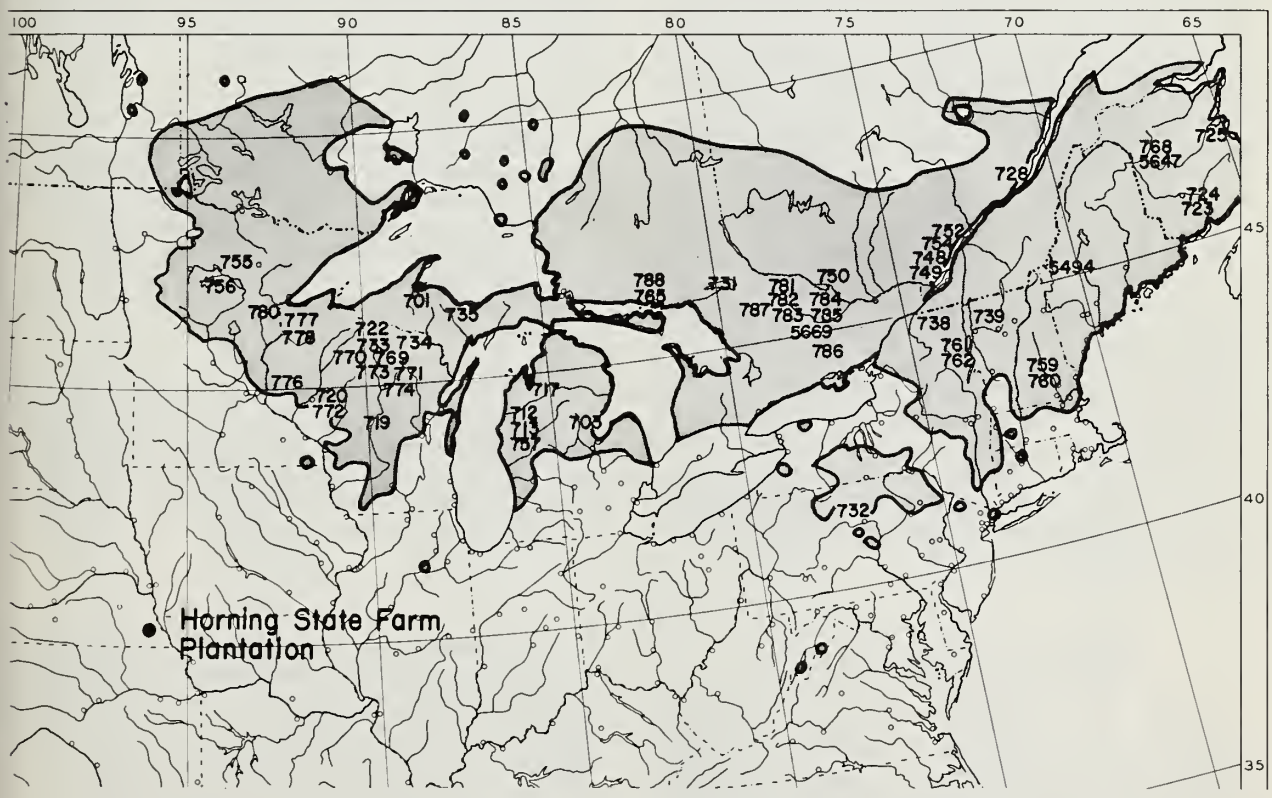

Figure 1.—Seed origins tested from within the natural range of red pine.

Previous Work

Although morphology of red pine is relatively uniform, some research has indicated that ecotypes have developed in the northern half of the Lake States, central Wisconsin, lower Michigan, the Northeast, and West Virginia (Rudolf 1957). Hough (1967) concluded, after a 25-year test in Pennsylvania of rangewide origins, that trees from southern origins generally were taller than those from northern origins, while tree forms were extremely uniform throughout. Sweet (1963) tested seven provenances in New Zealand for 6 years, and found that origins from climates with high mean annual temperatures and long growing seasons grew faster than others, and a Sturgeon Falls, Ontario, origin grew fastest.

Trees from lower Michigan were 8 percent taller than average at age 11 in 8 plantations of 77 provenances in the North Central States (Wright et al. 1972), whereas trees from New Brunswick, Manitoba, and western Ontario seed sources were 8 percent shorter than average. (The experimental planting reported here is one of the plantations studied by Wright et al., but additional years of growth are now available for more detailed information on performance in Nebraska.)

A Statewide provenance study in Michigan found lower Michigan trees 10 percent taller than upper Michigan trees after 10 years in a lower Michigan plantation, but only 3 percent taller when grown in an upper Michigan plantation (Yao et al. 1971).

Fowler (1965) compared cone length, number of seeds per cone, percent full seed, seed weight, percent germination, number of days to germinate, hypocotyl length, and number of cotyledons of 34 red pine trees from 9 climatic zones within their natural range. Number of cotyledons per seedling was the only characteristic correlated with provenance latitude: northern origins had fewer cotyledons than southern origins.

Other characteristics of red pine such as foliage color, needle length, bud characteristics, and hardiness are uniform among provenances (Wright et al. 1963).

Methods and Materials

Seeds of 77 origins were sown in the Michigan State University nursery at East Lansing during the spring of 1960. The 3+0 seedlings of 54 origins (fig. 1, table 1) were lifted, shipped by air, and planted in May 1963 at the Horning State Farm experimental area near Plattsmouth, in southeastern Nebraska. The planting site, at 96° west longitude and 41° north latitude, is on a gentle northfacing slope of silt loam soils derived from loess. Growing season averages 170 days and mean annual precipitation is 30 inches. Because the site had not been cultivated for several years, it was plowed and fallowed in 1962 in preparation for planting.

Seedlings were machine planted 5 feet apart in 16 rows spaced 10 feet apart. Each of the 54 provenances were replicated 8 times in 4-tree linear plots, which were randomly allocated in each replication. Surplus trees of all provenances were planted adjacent to the plantation. Maintenance of the plantation from 1963 through 1967 involved mowing between rows during the growing season, and applying Simazine spray in early spring at a rate of 4 pounds per acre in a 20-inch band along both sides of each tree row. The plantation was not mowed or sprayed after 1968.

Tree heights were measured following the growing season from 1965 through 1969 and again in 1971. Survival of initial plantings was checked after the first and second years, and dead seedlings were replaced by hand planting surplus stock. The trees were checked periodically for presence of insects and diseases and possible winter damage. The following additional measurements and observations were made during September 1973:

- Total height.
- Form rating—A numerical rating from 0 to 40 based on the sum of four characteristics: (1) branch angle, (2) stem straightness, (3) crown density, and (4) crown balance.[2]
- Average length of 1-year-old needles.
- Cone production.
- Average annual height growth for the last 7 years.

Analysis of variance and multiple-range tests were performed to determine any significant differences in total height, growth rate, or form among seed sources. An isodata cluster analysis[3] was made to determine and geographical patterns of variation.

[2]*Branch angle refers to the angle of the lateral branches relative to the main stem. Crown balance refers to the uniformity of lateral branching on all sides of a tree. Each of the four morphological characteristics was given a numerical rating from 0 to 10. The sum of the four equals the form rating. Trees with acute branch angles, straight stems, dense crowns, and balanced crowns were given the highest form ratings.*

[3]*An isodata cluster analysis groups seed sources that are morphologically similar.*

Table 1.--Data on seed origin locations of red pine tested in eastern Nebraska

Michigan State Univ. origin no.	State or Province	Place	North latitude	West longitude	Elevation	
			degrees	*degrees*	*feet*	*meters*
768	New Brunswick	Hamilton Brook	47.0	67.4	400	122
5647	New Brunswick	Limestone	46.8	67.6	450	137
725	New Brunswick	Despres Lake	46.6	65.6	300	91
724	New Brunswick	Grand Lake	46.0	66.1	75	23
723	New Brunswick	Camp Gagetown	45.8	66.3	--	--
728	Quebec	Loretteville	46.9	71.4	475	145
754	Quebec	Rawdon	46.2	73.9	202	62
752	Quebec	St. Philomene	46.1	73.3	62	19
748	Quebec	Berthierville	46.1	73.3	54	16
749	Quebec	Berthierville	46.1	73.3	54	16
788	Ontario	Sand Lake	46.6	82.2	1,400	427
731	Ontario	Sturgeon Falls	46.4	79.9	--	--
765	Ontario	Massey	46.1	82.2	--	--
731	Ontario	Deep River	46.0	77.4	--	--
782	Ontario	Chalk River	46.0	77.4	--	--
784	Ontario	Chalk River	46.0	77.6	--	--
785	Ontario	Chalk River	46.0	77.4	--	--
750	Ontario	Ft. Coulonge	46.0	76.6	447	136
5669	Ontario	Chalk River	46.0	77.5	--	--
783	Ontario	Chalk River	45.9	77.4	--	--
787	Ontario	Niven	45.8	78.0	750	229
786	Ontario	Griffith	45.2	77.2	850	259
5494	Maine	Flagstaff Lake	45.2	70.1	1,200	366
759	New Hampshire	Henniker	43.2	71.8	400	122
760	New Hampshire	Weare	43.1	71.7	600	183
739	Vermont	Checkerberry	44.6	73.1	200	61
738	New York	Paul Smiths	44.5	74.3	1,675	511
761	New York	Upper Jay	44.3	73.7	--	--
762	New York	Upper Jay	44.3	73.7	--	--
732	Pennsylvania	Renova	41.3	77.8	1,300	396
717	Michigan (LP)	Fife Lake	44.5	85.5	1,200	366
713	Michigan (LP)	Yuma	44.5	86.0	1,000	305
712	Michigan (LP)	Pomona	44.5	86.0	900	274
757	Michigan (LP)	Boon	44.2	85.5	1,300	396
703	Michigan (LP)	Gladwin	43.8	84.5	--	--
701	Michigan (UP)	Baraga	46.9	88.4	560	171
735	Michigan (UP)	Marquette	46.6	87.5	725	221
777	Wisconsin	Brule	46.5	91.6	974	297
734	Wisconsin	Boulder Junction	46.4	89.6	--	--
778	Wisconsin	Gordon	46.3	91.6	1,060	323
733	Wisconsin	Woodruff	46.1	89.7	--	--
722	Wisconsin	Sayner	46.0	89.5	--	--
770	Wisconsin	Worcester	45.8	90.4	1,500	457
769	Wisconsin	Three Lakes	45.8	89.1	1,650	503
771	Wisconsin	Crescent	45.6	89.7	1,100	335
773	Wisconsin	Bradley	45.5	89.8	1,100	335
774	Wisconsin	Post Lake	45.5	88.8	1,000	305
776	Wisconsin	Cylon	45.2	92.0	1,100	335
720	Wisconsin	Washington	44.8	91.4	1,000	305
772	Wisconsin	Fall Creek	44.8	91.4	1,000	305
719	Wisconsin	Pittsville	44.3	89.8	1,030	314
755	Minnesota	Winnibigoshish Lake	47.5	94.3	1,350	412
756	Minnesota	Leech Lake	47.3	94.5	1,350	412
780	Minnesota	Cloquet	46.7	92.5	1,265	386

Results

Seedling Survival

Overall survival was 79.4 percent after one growing season, and 78.7 percent after two growing seasons. Survival varied from 97 percent for three origins (Niven, Ont.—787, Berthierville, Que.—748, and Baraga, Mic.—701) to 34 percent (Limestone, N.B.—5647) (table 2). Mortality after the second year was negligible, except that caused by a surface fire in 1968 which spread from adjacent land through a portion of the plantation. All trees damaged by fire were subsequently excluded from analysis. Survival rates were unrelated to latitude or longitude of seed origin.

Height and Growth Rates

Trees from St. Philomene, Quebec (752) were the tallest after 11 years. They averaged 18.9 feet in height, 11 percent taller than the plantation average of 17.1 feet (table 2). Individual trees of this origin varied in height from 20.5 feet, the second tallest tree in the plantation, to 16.2 feet. Height measurements taken in 1966, 4 seasons after planting, showed these Quebec origin trees to be tallest even at the that time, averaging 4.4 feet.

Over the last 7 years,[4] the fastest height growth rate was 2.1 feet per year for eight origins, compared to a plantation average of 1.9 feet per year. The fastest growing individual tree, from Upper Jay, New York (762), averaged 2.4 feet in annual height growth for the last 7 years.

Analyses of variance indicated that some differences in total heights and height growth rates between origins were significant. Multiple range tests showed that trees of the tallest origin (St. Philomene, Que.—752, which averaged 18.9 feet) were significantly taller than trees of some 27 origins, which averaged 17.2 feet or less. Similarly, the fastest rate of height growth (2.1 feet per year for 8 origins) was significantly greater than the 1.8 feet per year or less of the 10 slowest growing origins. Neither heights nor growth rates were correlated with latitude, longitude, or elevation of seed origin.

[4]*Average annual height increments were based on the last 7 years, whereas total heights were measured after 11 years. Thus the tallest trees did not necessarily have the fastest growth rates.*

Table 2.--Survival and height of red pine origins in eastern Nebraska

Michigan State Univ. origin number		2-year survival	Height		Mean annual height growth 1967-73	Basis: trees
			11-year total	Percent of plantation mean		
		percent	*feet*	*percent*	*feet*	*no.*
QUE	752	91	18.9 [1]	111	2.1	16
WIS	772	78	18.8	110	2.1	9
MIC	735	78	18.7	109	2.1	2
VT	739	84	18.6	109	2.0	4
ONT	788	69	18.5	108	2.1	6
MIC	712	84	18.3	107	2.1	10
WIS	720	72	18.1	106	2.0	5
NY	762	88	18.1	106	2.0	11
ONT	731	81	18.0	105	2.1	3
ONT	781	88	18.0	105	2.1	2
WIS	777	78	17.9	105	2.0	7
ONT	765	84	17.9	105	2.0	4
MIC	703	84	17.9	105	2.0	8
WIS	773	81	17.9	105	2.0	9
NH	760	84	17.9	105	2.0	8
ONT	785	75	17.8	104	2.0	10
NY	761	84	17.8	104	2.0	12
ONT	787	97	17.8	104	2.0	10
QUE	749	62	17.8	104	2.0	8
MIC	713	84	17.8	104	2.0	11
QUE	754	69	17.7	104	2.0	3
ONT	5669	53	17.6	103	2.1	12
ONT	783	81	17.6	103	2.0	14
QUE	748	97	17.3	101	2.0	8
WIS	734	81	17.3	101	2.0	10
WIS	776	64	17.2	101	2.0	8
MIN	780	72	17.2	101	2.0	3
WIS	722	84	17.2	101	2.0	10
WIS	733	72	17.2	101	2.0	6
WIS	778	91	17.1	100	1.9	13
MIN	756	84	17.1	100	2.0	10
ONT	782	82	17.1	100	1.9	9
WIS	770	84	17.1	100	2.0	12
ONT	750	84	17.0	99	1.9	6
ONT	784	78	17.0	99	1.9	5
ONT	786	81	16.9	99	1.8	5
WIS	771	88	16.7	98	1.8	8
WIS	774	72	16.7	98	2.0	7
MIC	757	75	16.7	98	1.8	9
NBR	768	75	16.7	98	1.9	9
WIS	719	84	16.4	96	2.0	6
NBR	724	88	16.4	96	1.9	11
NY	738	78	16.2	95	1.8	6
NBR	723	84	16.1	94	1.8	3
MIN	755	75	16.1	94	1.8	1
MAI	5494	50	15.8	92	1.9	13
MIC	701	97	15.6	91	1.7	10
NBR	5647	34	15.6	91	1.9	11
QUE	728	81	15.3	89	1.7	1
NH	759	67	14.7	86	1.5	6
NBR	725	78	14.3	84	1.6	4
WIS	769	--	14.1	82	1.7	10
MIC	717	--	12.5	73	1.4	4
PA	732	--	12.0	70	1.4	7
Plantation average		79	17.1	100	1.9	

[1]Duncan's range test: Means within same bracket do not differ at the 5% level. Means of equal value may be separated by brackets due to rounding off.

Form

Form ratings for origins ranged narrowly from 26 to 33, with a plantation average of 29.3 (table 3). Individual trees rated as high as 37 (fig. 2) and as low as 18. Trees from Cape Gagetown, New Brunswick (723), had the highest form ratings. An analysis of variance indicated no significant differences in form among the 54 origins. Multiple range tests showed only four origins with form ratings significantly lower than the other 50.

Figure 2.—A Gordon, Wisconsin, tree exhibits a straight stem, dense foliage, and a compact crown. Form rating was 37.

Other Characteristics

Average needle length also ranged only slightly among origins, from 5.0 to 6.0 inches (table 3). Foliage color during the growing season was uniformly dark green throughout the plantation; during dormancy foliage was a duller green, but still uniform.

Table 3.--Form, needle length, and cone production of red pine origins 11 years after planting in eastern Nebraska

Michigan State Univ. origin number		Average form rating[1]	Average needle length	Average cone production[2]
			inches	*per tree*
NBR	723	33.0	5.3	M
MIC	735	32.5	6.0	L
ONT	765	31.5	6.0	M
NBR	725	31.2	5.4	L
WIS	720	31.0	5.9	L
NBR	5647	30.7	5.6	L
QUE	754	30.7	5.5	L
ONT	787	30.6	5.7	L
ONT	784	30.4	5.5	L
MIC	713	30.3	5.9	L
ONT	788	30.2	5.6	L
NH	760	30.1	5.5	L
NBR	768	30.1	5.6	L
WIS	772	30.0	5.7	L
ONT	750	30.0	5.5	L
ONT	781	30.0	5.0	M
WIS	774	29.9	5.8	L
QUE	752	29.8	5.7	M
NBR	724	29.7	5.6	L
QUE	748	29.6	5.6	L
NY	761	29.6	5.5	L
ONT	783	29.5	5.7	L
QUE	749	29.5	5.6	L
MIC	703	29.5	5.2	L
ONT	786	29.4	5.6	M
MIC	712	29.4	5.5	L
ONT	731	29.3	5.5	M
NH	759	29.3	5.3	L
MIC	701	29.2	5.4	L
NY	762	29.2	5.8	L
ONT	785	29.1	5.7	L
WIS	778	29.0	5.6	M
WIS	773	29.0	5.2	L
QUE	728	29.0	5.0	L
ONT	5669	28.9	5.6	L
WIS	770	28.9	5.5	L
VT	739	28.8	5.9	M
WIS	771	28.8	5.8	L
WIS	719	28.7	5.9	L
NY	738	28.7	5.7	M
MIN	780	28.7	5.3	M
WIS	733	28.7	5.2	L
WIS	734	28.6	5.4	L
MIN	756	28.4	5.4	L
WIS	777	28.3	5.3	L
MIC	757	28.2	5.6	M
WIS	722	28.1	5.8	L
MAI	5494	28.1	5.8	L
ONT	782	28.0	5.5	M
MIC	717	28.0	5.2	L
WIS	776	27.8	5.1	L
PA	732	27.3	5.9	L
WIS	769	27.2	5.6	L
MIN	755	26.0	6.0	H
Plantation average		29.3	5.6	

[3] Duncan's range test: Means within same bracket do not differ at the 5% level. Means of equal value may be separated by brackets due to rounding off.

[1] 0 = lowest 40 = highest

[2] L = <20 cones; M = 20 to 40 cones; H = >40 cones.

Cone production for all origins was relatively low. Only 13 of the 54 origins averaged more than 20 cones per tree (table 3). Individual trees of the same origin often ranged from less than 20 to well over 40 cones per tree, however. Cone production was not correlated with seed origin.

No damage from insects or disease has been observed in the plantation. Heavy wet snow or freezing rain caused greatest physical damage (fig. 3). In no instance did this breakage cause mortality, however, and generally the tree crown was not noticeably deformed.

The isodata cluster analysis, which compared total height, growth rates, and form ratings of all origins, revealed no clearly defined geographical ecotypes within the species. On the contrary, all measurements except height and growth rates portrayed a uniform species.

Discussion

The separate ecotypes referred to by Rudolf (1957) were not identifiable in this study. Heights and growth rates varied sufficiently, however, that certain origins can be selected for tree planting programs where rapid height growth is desired.

The plantation average growth rate of 1.9 feet per year is excellent for conifers, and compares favorably with broadleaf species in eastern Nebraska. Seven tests of the same red pine origins, conducted simultaneously in Michigan, Wisconsin, Minnesota, and Indiana, produced slower growing trees (Wright et al. 1972). Shorter growing seasons and less fertile soils in the Lake States were probably responsible for slower growth, although four of the test sites in southern Michigan and eastern Indiana had growing seasons only 10 days shorter than Nebraska. However, those sites averaged 5 more inches of precipitation per year than at Horning, Nebraska.

Height measurements of the Nebraska plantation in 1971 indicated that, collectively, four of the five lower Michigan origins were taller than other geographically related origins, averaging 106 percent of the plantation mean height. In 1973, these same origins averaged only 103 percent of the plantation mean, and only one origin (Pomona, Michigan—712) from lower Michigan was among the 10 tallest. No permanent pattern of superior height growth by geographically related origins has been established in the plantation. It is unlikely that any such pattern will develop because of the uniformity among origins displayed thus far.

Trees in the plantation were vigorous, and the absence of disease and insect damage was encouraging. Christmas tree growers near Lincoln, Nebraska, 50 miles west of the study area, have reported young red pines damaged by tip moths (*Rhyacionia* sp.) when planted near infested stands of ponderosa pine (*Pinus ponderosa* Laws.) Tip moth infestations appear to increase further west in Nebraska. These insects, which do not cause mortality but will re-

Figure 3.—Severe snow damage which bent lower branches and caused some breakage.

duce terminal growth, can be chemically controlled (Roselle 1973, Sexson and Roselle 1974).

Information regarding the ability of red pine to grow in central and western Nebraska is scanty. Only small portions of red pine stands planted early in this century on the Bessey District, Nebraska National Forest, are still living. High mortality resulted from periods of drought, severe tip moth damage during juvenile growth, and a 1965 fire. For these reasons other species are considered more suited for conditions in central and western Nebraska.

In eastern Nebraska, on the other hand, all of the tallest 27 origins (table 2) should be satisfactory for windbreak plantings. The St. Philomene, Quebec, (752) origin, tallest in this study, also grew rapidly in most of the Lake States studies (Wright et al. 1972). It was tallest, 19 percent above average, in the Indiana provenance test; second tallest, 20 percent above average, in the Wisconsin provenance test; and 11 and 12 percent above average height in two Michigan plantations. Because of its consistent performance, this seed origin is recommended over all others for use in eastern Nebraska windbreaks. Landowners interested in growing trees for posts, poles, and lumber should also consider obtaining seedlings of this fast-growing origin. Correspondence with the nursery supervisor at Berthierville, Quebec, indicates that seeds of this origin can be obtained.

New Brunswick origins, in contrast, averaged only 92 percent of plantation average heights in both the Lake States and Nebraska, and are not recommended for eastern Nebraska.

Average form ratings for the plantation were very high (29.3). The uniformly dense, oval, dark green crowns give the red pine plantation an esthetic advantage over some of the other pine plantations at Horning. Stems were consistently straight and crowns symmetrically balanced in all origins. Lower branches were persistent to ground level. These factors, combined with an average needle length of 5.6 inches, created a dense, compact crown that is desirable for windbreaks. Because there were no significant differences in form, all origins tested can be used for plantings in eastern Nebraska where high esthetic value is desirable, but rapid height growth is less important, such as for Christmas trees. St. Philomene (752) and Fall Creek, Wisconsin (772), seed origins are recommended where both rapid growth and superior form are desired, as in greenbelts, parks, roadsides, and landscaping projects. Although the Marquette, Michigan (735), origin grew rapidly, there were insufficient trees remaining on which to base a reliable recommendation.

The good survival, rapid growth, excellent form, and high esthetic value demonstrated by red pine in this study proves that it can be successfully grown for shelterbelts, Christmas trees, and landscaping purposes in eastern Nebraska. Red pine is not recommended for central and western Nebraska, however. For maximum success, red pine should not be planted adjacent to stands of pines infested with tip moth.

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Keywords: *Pinus resinosa*, provenances, windbreaks, ornamentals, growth, tree form.

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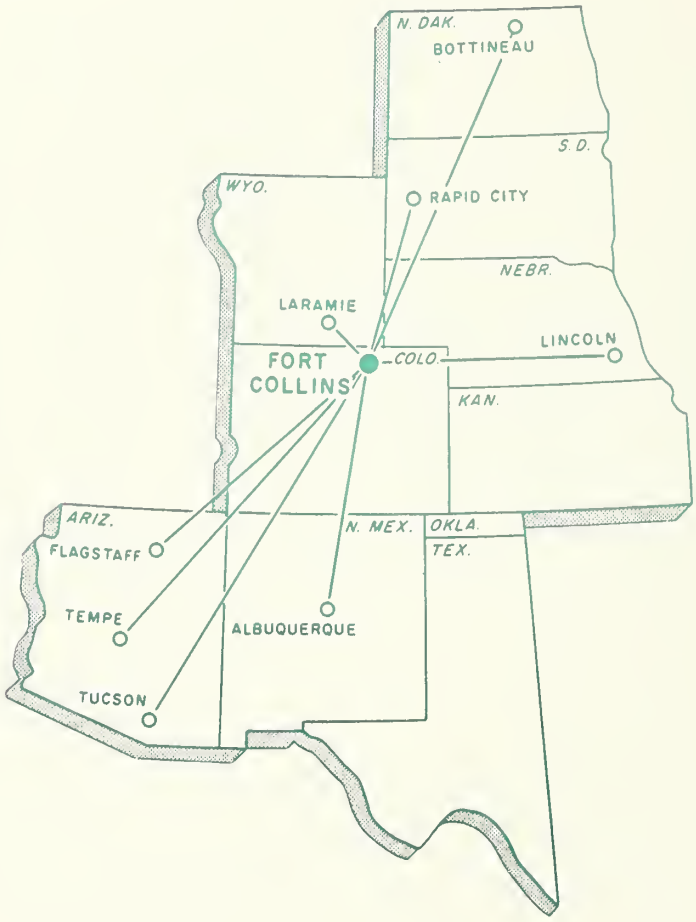
Although this report discusses research involving pesticides, such research does not imply that the pesticide has been registered or recommended for the use studied. Registration is necessary before any pesticide can be recommended. If not handled or applied properly, pesticides can be injurious to humans, domestic animals, desirable plants, fish, and wildlife. Always **read** and **follow** the directions on the pesticide container.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